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Accelerating ATM Optimization Algorithms Using High Performance Computing Hardware

Optimal Synthesis, Inc.

Technical Abstract

NASA is developing algorithms and methodologies for efficient air-traffic management. Several researchers have adopted an optimization framework for solving problems such as flight scheduling, route assignment, flight rerouting, nationwide traffic flow management (TFM) and dynamic airspace configuration. Computational complexity of these problems have led investigators to conclude that in many instances, real time solutions are computationally infeasible, forcing the use of relaxed versions of the problem to manage computational complexity. The primary objective of the proposed research is to accelerate optimization algorithms that play central roles in NASA's ATM research, by parallel implementation on emerging high performance computing (HPC) hardware. The Phase I R&D effort implemented a Simplex-based Dantzig-Wolfe (DW) decomposition solver that exploits both coarse-grain and fine-grain parallelism in the sub-problem and master iterations of the DW decomposition. The implementation also exploits the sparsity in the problems, to manage both memory requirements and run-times for large-scale optimization problems. This parallel implementation was used to solve a Traffic Flow Management (TFM) problem with 17,000 aircraft (linear program with 7 million constraints), in 15 seconds. The implementation is 30¿ faster than the exact same code running on the CPU. It is also 16¿ faster than the NASA's current solution that implements parallel DW decomposition using the GNU Linear Programming Kit (GLPK) on an 8-core computer with hyper-threading. Based on the promising Phase I results, the Phase II R&D effort will explore Mixed Integer Linear Programming (MILP) methods to solve optimization problems arising in the terminal area and on the airport surface, in addition to DW decomposition for the nationwide TFM problem. Phase II work will develop operational prototypes of the algorithm implementations on HPC hardware, and deliver them to NASA for further evaluation.

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Probabilistic Remaining Useful Life Prediction of Composite Aircraft Components

Global Engineering and Materials, Inc

Technical Abstract

A Probabilistic Fatigue Damage Assessment Network (PFDAN) toolkit for Abaqus will be developed for probabilistic life management of a laminated composite structure with both microcracking induced stiffness degradation and cyclic loading induced delamination crack growth without remeshing. It is based on a high fidelity Fatigue Damage Assessment Network (FDAN) which includes 1) a coupled continuum damage and discrete crack model for ply damage characterization; 2) a moment schema finite element coupled with XFEM for efficient crack growth simulation in a thin ply; 3) a mixed mode fatigue delamination module to account for the mode mixity and failure mode interaction; and 4) an adaptive fracture process zone model for mesh independent delamination growth. A reduced-order model of FDAN will be generated using a combined response surface and a Gaussian process surrogate model builder to perform the subsequent probabilistic analysis efficiently. For the module verification and validation, experimental studies at the sub-component level will be performed along with the use of a damage monitoring and characterization system. The developed toolkit will be used to perform damage prognosis and risk informed life management using SHM data. GEM has secured commitments for technical support and commercialization assistance from Clarkson University, Sikorsky Aircraft, and Boeing.

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